

# Chelation therapy and chelating agents of Ayurveda

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## Abstract

Consumption of metals and minerals are very common in today's life either in the form of medicine or in the form of commercial products. However, the accumulation of free metals above the normal level in human body is the prime cause of metal toxicity. To remove this toxicity from human body chelation therapy is adopted by modern system of medicine, where different chelating agents are described. Chelation therapy is the preferred medical treatment for reducing the toxic effects of metals. Chelating agents are capable of binding to toxic metal ions to form complex structures which are easily excreted from the body removing them from intracellular or extracellular spaces. Ethylenediaminetetraacetic acid and 2,3-Dimercaprol are some of the common chelating agents, which have been used for the chelation of lead or arsenic poisoning. However, serious side effects of these agents have been reported by causing the loss of essential metals and minerals from the body. This may lead researchers to develop less toxic analogs. In *Ayurveda* (*Ayur* = life, *Veda* = science; the science of life) system of medicine, metals and minerals in the form of medicines (*Rasaushadhies*) are frequently used to treat different diseases. Yet, the ancient scholars of *Ayurveda* while practicing came to know about the ill-effects of these medicines on human body which may be caused due to the use of medicines made from improper processed metals and minerals. At the same time, they advised to administer various natural substances in the form of antidotes such as honey, ghee, cow's milk, garlic, coriander, turmeric, and coconut water to remove ill effects or toxicity occurred from these medicines. These natural antidotes may consider as chelating agents of *Ayurveda*, which not only helpful to remove the toxic effects of metal and minerals without causing any side effects but also protect the loss of essential elements from the body. Thus, in this review study, we have tried to correlate the natural antidotes as explained in *Ayurveda* vis-à-vis with the term chelation or chelating agents of contemporary science.

**Key words:** Antidote, *Ayurveda*, chelating agent, chelation therapy, toxicity

## INTRODUCTION

The numbers of metals and minerals are present in our environment either in natural sources like plants and soil or inartificial sources like in commercial products or in environmental pollution. Some of these like copper, iron, and zinc play important and key roles in our bodies. Their multiple industrial, domestic, agricultural, medical, and technological applications have led to their wide distribution in the environment; raising concerns over their potential effects on human health and the environment. Their toxicity depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals. Because of their high degree of toxicity, arsenic, cadmium, chromium, lead, and mercury rank among the priority metals that

are of public health significance.<sup>[1]</sup> People may get small amounts of metals in their body through food, water, air, commercial products. Examples of these are lead, which is found in paint in old homes as well as in many other sources; arsenic, which can be found in well water and wood products; mercury, which can build up in fish that we eat.<sup>[2]</sup> Many of the metals (such as zinc, copper, chromium, iron, and manganese) are essential for our body function but required in very small amounts. However, if these metals accumulate in the body, in concentrations sufficient

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to cause poisoning, then serious damage may occur.<sup>[3]</sup> Some metals are toxic when they form poisons soluble compounds.<sup>[4]</sup> In the case of lead, any measurable amount may have negative health effects. Often heavy metals are thought as synonymous, but lighter metals may also be toxic in certain circumstances, such as Beryllium and Lithium.<sup>[5]</sup>

Chelation therapy is a process to remove toxic metals and minerals from the body using chelating agents.<sup>[6]</sup> A chelating agent is a substance whose molecules can form several bonds to a single metal ion. In other words, a chelating agent is a multidentate ligand. An example of a simple chelating agent is ethylenediaminetetraacetic acid (EDTA).<sup>[6]</sup>

The Ayurvedic system of medicine had stood the test of time for four millennia or more. The ancient seers of *Ayurveda* had found that drugs of different origin (herbal, metal, or animal) in addition to codes of conduct and dietary regulations were suitable tools to maintain health in healthy and eradicating diseases in diseased person.<sup>[7]</sup> The use of metallic preparations in healthcare is a unique feature in this system. Processed metals (mercury, gold, silver, lead, zinc, copper, etc.), gems, and various minerals (mica, chalcopyrites, etc.) were used very frequently by seers of the Indian tradition in different disease conditions with great authority.<sup>[8]</sup> It is generally claimed that these metals and minerals are detoxified during the highly complex manufacturing processes described in Ayurvedic, especially *Rasa Shastra* (*Ayurvedic* pharmaceuticals) texts.<sup>[9]</sup> *Charaka Samhita*, one of the pioneer texts of *Ayurveda* also holds ample of references regarding the use of metals for different purposes.<sup>[10]</sup>

This study is the compilation of some methods and substances which were described in *Ayurvedic* classics for the removal of toxins substance caused by some poisonous herbs or improper processed metals or minerals. There are certain methods which are described in classics to make body get rid of toxins, using of antidotes and that method may be termed as chelation therapy of *Ayurveda* and the substances, which are used as antidotes in these methods may be termed as chelating agents of *Ayurveda*.

## GENERAL ANTIDOTES OR CHELATING AGENT OF AYURVEDA<sup>[11]</sup>

*Tankan* (borax), *Gandhak* (sulphur), *Saindhav Lavana* (rocksalt), *Churnodaka* (lime water), *Triphala Kwath*, ginger juice, *Arjuna* (*Terminalia arjuna*), turmeric, lemon juice, *Maricha* (black pepper), *Kumari Swarasa* (aloe vera juice), coriander, honey, cow's milk, goat's milk, cow's ghee, cow's urine, etc., are some common antidotes which are used to subside the toxic symptoms and to remove the toxic effects of administration of improper processed metals and minerals.

## METALS AS MEDICINE IN CONTEMPORARY SYSTEM OF MEDICINE

Metals have been used in treatments since ancient times. The Ebers Papyrus from 1500 BC is the first written account of the use of metals for the treatment and describes the use of copper to reduce inflammation and the use of iron to treat anemia. Recently, metals have been used to treat cancer, by specifically attacking cancer cells and interacting directly with DNA. The positive charge on most metals can interact with the negative charge of the phosphate backbone of DNA.<sup>[12]</sup> Some of the examples of metals used in treatment are described below.<sup>[13]</sup>

### Platinum

Platinum-based compounds have been shown to specifically effect head and neck tumors. These coordination complexes are thought to act to cross-link DNA in tumor cells.

### Gold

Gold salt complexes have been used to treat rheumatoid arthritis. The gold salts are believed to interact with albumin and eventually be taken up by immune cells, triggering anti-mitochondrial effects, and eventually cell apoptosis. This is an indirect treatment of arthritis, mitigating the immune response.

### Lithium

$\text{Li}_2\text{CO}_3$  can be used to treat prophylaxis of manic-depression behavior.

### Zinc

Zinc can be used topically to heal wounds.  $\text{Zn}^{2+}$  can be used to treat the herpes virus.

### Silver

Silver has been used to prevent infection at the burn site for burn wound patients.

### Platinum, Titanium, Vanadium, Iron

Di-aminedi-chloroplatinum, titanium, vanadium, and iron have been shown to react with DNA specifically in tumor cells to treat patients with cancer.

### Gold, Silver, Copper

Phosphine ligand compounds containing gold, silver, and copper have anti-cancer properties.

## REMEDIES FOR REMOVAL OF TOXIC ELEMENT/METAL POISONING<sup>[14]</sup>

Heavy metal poisoning is the accumulation of heavy metals, in toxic amounts, in the soft tissues of the body. Symptoms and physical findings associated with heavy metal poisoning vary according to the metal accumulated. The definition may also include trace elements when considered in abnormally high, toxic doses.

- Chelation: Certain foods, herbal drinks, and herbs actively bind to a range of minerals or metals. They are then excreted or washed away from the body
- Saturation: Sufficient and wide range of minerals in diet and cells become saturated with the variety of minerals they need. Toxic minerals are then likely to be excreted rather than taken up. Some minerals are also antagonistic to each other, and a high level of one prevents the uptake of another. Example: Iodine saturation prevents the uptake of radioactive iodine pollution, and the absorption of other halogens (chlorine, bromine, fluorine)
- Antioxidants: A diet high in antioxidant nutrients and enzymes protects from toxic minerals.

An option for treatment of metal poisoning may be chelation therapy, which is a technique which involves the administration of chelation agents to remove metals from the body. Chelation therapy is the use of chelating agents to detoxify poisonous metal agents such as mercury, arsenic, and lead by converting them to a chemically inert form that can be excreted without further interaction with the body and was approved by the U.S. Food and Drug Administration in 1991.<sup>[15]</sup> Chelation describes a particular way that ions and molecules bind metal ions. According to the International Union of Pure and Applied Chemistry, chelation involves the formation or presence of two or more separate coordinate bonds between a polydentate (multiple bonded) ligand and a single central atom. Usually, these ligands are organic and are called chelants, chelators, chelating agents, or sequestering agents.<sup>[16]</sup>

Chelation therapy is a medical procedure that involves the administration of chelating agents to remove heavy metals from the body. Chelation therapy must be administered with care as it has a number of possible side effects including death.<sup>[17]</sup>

Some of the risks while using chelating agents in contemporary science:

1. Chelators bind to heavy metal or metal particles, but they can also bind to important minerals in body, such as calcium and iron, which are essentials for human body
2. Although chelating agents can be beneficial in cases of heavy metal poisoning, sometimes chelating agents can also be dangerous. The use of disodium EDTA instead of calcium EDTA has resulted in fatalities due to hypocalcemia

3. Side effects of chelation therapy include dehydration, low blood calcium, harm to kidneys, increased enzymes as would be detected in liver function tests, allergic reactions, and lowered levels of dietary elements
4. When administered inappropriately, chelation therapy brings the risk of cancer, neurodevelopment disorder even death.

## USE OF METALS AND MINERALS IN INDIAN SYSTEM OF MEDICINE (AYURVEDA)

The Ayurvedic system of medicine has a great antiquity, dating back to about 5000 years B.C.<sup>[8]</sup> *MateriaMedica* of *Ayurveda* contain resources in the form of drugs derived from plant, animal, metal and mineral sources the use of which have been advocated in various different pathological manifestations.<sup>[18]</sup> During the medieval period, with the advent of *Rasa Shastra*, use of certain metals and minerals in Ayurvedic therapeutics increased. *Rasa Shastra*, an integral part of *Ayurveda*, deals with the drugs of mineral origin, and details their varieties, characteristics, processing techniques, properties, therapeutic uses, possibilities of developing adverse effects and their management, etc., in a comprehensive way. Although the roots of this science (*Rasa Shastra*) exist in the ancient texts of Indian civilization, its development as an independent system of therapy started around the 8<sup>th</sup> century A.D. *Ayurvedic* classics written before that time like *Charaka Samhita* and *Sushruta Samhita*, etc., contain descriptions of metals and minerals, and their processing techniques.

### Classification of *Rasa dravya*<sup>[19]</sup>

Using processed mineral/metal in health care is the unique characteristic feature of *Rasa Shastra*. Various herbal or animal resources are used during different pharmaceutical procedures of these minerals/metals, which convert them into bioassimilable forms. All these metals such as *Parada* (mercury), *Swarna* (gold), *Rajata* (silver), *Tamra* (copper), and *Naga* (lead) have known to the seers for centuries to possess healing powers as recorded in ancient texts. These processed metals/minerals are said to be the reservoirs of *Prana* (energy). All these metals/minerals described in *Rasa Shastra* are categorized into different categories as shown in Table 1<sup>[19]</sup> and their utilization in therapeutics in Table 2.<sup>[20,21]</sup>

Many of the *Ayurvedic* formulations do contain metals or minerals, etc., as an integral component, if not used by following proper *Ayurvedic* pharmaceuticals processes may show symptoms of toxicity. Seers were well versed about this fact and documented the toxic effects in their respective classics. A brief about the same is tabulated at Table 3.<sup>[22]</sup>

**Table 1:** Classification of *Rasa Dravya* in Ayurvedic science

S. No	Classification	Basis of Classification	No. of Dravya	Name of Dravya (Drug)
1	<i>Rasa</i>	Prime <i>Dravya</i>	1	<i>Rasa</i> (Mercury)
2	<i>Maha Rasa</i>	Substances primely used in the processing of Parada ( <i>Mercury</i> )	8	<i>Abhraka</i> (Biotite), <i>Vaikrant</i> (Tourmaline), <i>Makshik</i> (Pyrite), <i>Vimal</i> (Iron Pyrite), <i>Shilajatu</i> ( <i>Asphaltum panjabinum</i> ), <i>Sasayak</i> (Copper Sulphate), <i>Chapal</i> (Bismuth ore), <i>Rasak</i> (Zinc ore)
3	<i>Upa- Rasa</i>	Next important to <i>Maha Rasa</i>	8	<i>Gandhak</i> (Sulphur), <i>Gairik</i> (Haematite), <i>Kashisa</i> (Ferrous sulphate), <i>Kankshi</i> (Alum), <i>Haratala</i> (Arsenic trisulphide), <i>Manhashila</i> (Arsenic dissulphide), <i>Anjana</i> (Lead ore), <i>Kankustha</i> (Ruhbarb).
4	<i>Sadharana Rasa</i>	Next important to <i>Upa-Rasa</i>	8	<i>Kampillaka</i> ( <i>Mallotus phillippinensis</i> ), <i>Gauripashan</i> (Arsenious Oxide), <i>Navsaadr</i> (Ammonium Salts), <i>Kaparda</i> (Marine Shell), <i>Vahnijara</i> (Ambargris) <i>Girisindor</i> (Red oxide of Mercury), <i>Hingula</i> (Red sulphide of Mercury), <i>Mridushringa</i> (Lead Oxide)
<b>5</b>	<b><i>Dhatu</i></b>	<b>Group of metals</b>		
i	<i>Suddha Loha</i>	Pure metals	4	<i>Swarna</i> (Gold), <i>Rajata</i> (Silver), <i>Tamra</i> (Copper), <i>Loha</i> (Iron)
ii	<i>Puti Loha</i>	Have low melting point and also melts with specified smell	3	<i>Naga</i> (Lead), <i>Vanga</i> (Tin), <i>Yashada</i> (Zinc)
iii	<i>Misra Loha</i>	Alloys	3	<i>Pittala</i> (Brass), <i>Kashya</i> (White copper), <i>Varta</i> (Bronze)
6	<i>Ratna</i>	Gems/precious stones	9	<i>Manikya</i> (Ruby), <i>Mukta</i> (Pearl), <i>Praval</i> (Coral), <i>Markata</i> (Emerald), <i>Pushparaga</i> (Topaz), <i>Heerak</i> (Diamond), <i>Neelam</i> (Saphire), <i>Gomeda</i> (Zircon), <i>Vaidurya</i> (Cat's eye)
7	<i>Upratna</i>	Semi-precious stones	6	<i>Vaikranta</i> (Turmaline), <i>Suryakanta</i> (Sunstone), <i>Chandrakanta</i> (Moon stone), <i>Rajavarta</i> (Lapis Lazuli), <i>Pairojaka</i> (Turquoise), <i>Sphatika</i> (Quartz)
8	<i>Sudha Varga</i>	Calcium compounds	12	<i>Sudha</i> (Lime), <i>Khatika</i> (Pipe clay), <i>Godanti</i> (Gypsum), <i>Sweta Anjana</i> (Calcite), <i>Mrigasringa</i> (Deer horn), <i>Shukti</i> (Pearl Oyster), <i>Shankha</i> (Conch Shell), <i>Kukkutanda Twak</i> (Egg Shell), <i>Shambuka</i> (Pila), <i>Samudraphena</i> (Cuttle fish bone), <i>Kurmapristha</i> (Tortoise bone), <i>Hastidant</i> (Elephant's Tusk)
9	<i>Sikta Varga</i>	Silicates compounds	4	<i>Dugdha Pashana</i> (Magnesium silicate), <i>Naga Pashana</i> (Serpentine), <i>Kausheyashma</i> (Asbestos), <i>Badarashma</i> (Silicate of Lime)
10	<i>Kshara Varga</i>	Alkaline nature	3	<i>Tankana</i> (Borax), <i>Sarja Ksara</i> (Mixture of Potassium Salt), <i>Yava Ksara</i> (Mixture of Potassium salt)
11	<i>Visha Varga</i>	Most poisonous plant	1	<i>Vatsanabha</i> (Aconitam ferex)
12	<i>Upvisha Varga</i>	Less poisonous plants	11	<i>Kupeelu</i> ( <i>Strychnos nuxvomica</i> ) <i>Ahiphena</i> ( <i>Papaver somniferum</i> ), <i>Jayapala</i> ( <i>Croton tiglium</i> ), <i>Dhattura</i> ( <i>Dhattura stramonium</i> ), <i>Bhanga</i> ( <i>Cannabis indica</i> ), <i>Gunja</i> ( <i>Abrus precatorius</i> ), <i>Bhallataka</i> ( <i>Semecarpus anacardium</i> ) <i>Arka</i> ( <i>Calotropis procera</i> ), <i>Snuhi</i> ( <i>Euphorbia nerifolia</i> ), <i>Langali</i> ( <i>Gloriosa superba</i> ), <i>Karaveer</i> ( <i>Nerium indicum</i> )

## CHELATION THERAPY IN INDIAN SYSTEM OF MEDICINE

Each and every medicine system has its own line of the treatment for removing toxin or poison caused by their respective medicines or any other toxic substance present in the body. In *Ayurveda*, poisoning/toxicity can be treated by some of these methods.

### Method I<sup>[23]</sup>

General rule for removing toxic elements from human body is quite logical any substance used for the purification of *Rasa/Visha* materials automatically has potent antidote properties attached to it. For examples:

1. Raw *Vimal* (Iron pyrite) get purified in *Meshshringi* juice (*Gymnema sylvestre*) while performing the



**Table 2: Therapeutics uses of *Rasa Dravyas* in different classics of *Ayurveda***

S. No	<i>Rasa Dravya</i> (Metals/ Minerals)	Therapeutic Uses	Reference
1	<i>Rasa</i> (Mercury)	In all diseases with suitable Adjuvant	
2	<i>Swarna</i> (Gold)	<i>Rasayana</i> , (Rejuvenative), <i>Ayushya</i> (Beneficial for life span) <i>Medhya</i> , (To enhance intellectual power) <i>Ojo Vardhaka</i> , (Energy Providing)	<i>Rasa Taringni</i> 15/69
3	<i>Rajata</i> (Silver)	<i>Balya</i> (Strength promoting), <i>Rasayana</i> , (Rejuvenative), <i>Medhya</i> (To enhance intellectual power) <i>Ayushy</i> (Beneficial for life span), <i>Ojo Vardhaka</i> , (Energy Providing)	<i>Rasa Taringni</i> 16/46-51
4	<i>Tamra</i> (Copper)	<i>Krimi</i> (Wormicidal), <i>Sthaulya</i> (Obese), <i>Arsha</i> (Piles), <i>Ksaya</i> , <i>Pandu</i> (Anaemia), <i>Kusta</i> (Leprosy), <i>Swasa</i> (Dyspnea), <i>Kasa</i> (Cough),	<i>Rasa Ratna Samuchya</i> 5/67
5	<i>Naga</i> (Lead)	<i>Prameha</i> , (Diabetes) <i>Gulma</i> (Abdominal Lump), <i>Arsha</i> (Piles), <i>Sweta pradara</i> (Leucorrhoea), <i>Grahani Roga</i> (Sprue)	<i>Rasa Ratna Samuchya</i> 5/171
6	<i>Vanga</i> (Tin)	<i>Krimi</i> (Worms), <i>Kshaya</i> , <i>Pandu</i> (Anaemia), <i>Pradara</i> (Leucorrhoea)	<i>Ayurveda Prakash</i> 3/152
7	<i>Manahashila</i> (As <sub>2</sub> S <sub>2</sub> )	<i>Swasa Kasa</i> (Respiratory Disorders) <i>Agnimandya</i> (Dyspepsia), <i>Kandu</i> (Itching)	<i>Rasa Taringni</i> 11/116
8	<i>Hartala</i> (As <sub>2</sub> S <sub>3</sub> )	<i>Kustha</i> (Leprosy), <i>Vishama Jwara</i> (viral fever), <i>Vrana</i> (Complexion Promoting), <i>Arsha</i> (Piles), <i>Apasmara</i> (Epilepsy), <i>Visarpa</i> (Erysipelas)	<i>Rasa Ratna Samuchya</i> 3/68
9	<i>Abharaka</i> (Biotite)	<i>Jawar</i> (Fever), <i>Kasa</i> (Cough), <i>Prameha</i> (Diabetes), <i>Arsha</i> (Piles)	<i>Rasa Ratna Samuchya</i> 2/2
10	<i>Makshik</i> (Copper Pyrite)	Eye disorders, <i>Prameha</i> (Diabetes), <i>Jawar</i> (fever), <i>Anindra</i> (Insomnia)	<i>Rasa Ratna Samuchya</i> 2/79-80
11	<i>Gauripashan</i> (As <sub>2</sub> O <sub>3</sub> )	<i>Kamla</i> (Jaundice), <i>Jawar</i> (Fever), Digestive disorders, <i>Svasa-Kasa</i> (Respiratory disorders)	<i>Rasa Taringni</i> 11/138-44

**Table 3: Classically quoted adverse effects through administration of improperly processed *Bhasma***

S. No	<i>Rasa Bhasma</i>	Adverse effects (if improperly processed)	Reference
1	<i>Rasa</i> (Mercury)	Burning sensation, Skin lesions, vomiting, Stiffness and even death	<i>Ayurveda Prakash</i> 1/366
2	<i>Swarna</i> (Gold)	<i>Ojas</i> decreases, Disease cause and even death	<i>Rasa Ratna Samuchaya</i> 5/20
3	<i>Rajat</i> (Silver)	Pyrexia constipation Impotency, lowering body resistance power	<i>Ayurveda Prakash</i> 9/92
4	<i>Tamra</i> (Copper)	Vertigo, Unconsciousness, Burning Sensation, Anorexia, Vomiting	<i>Ayurveda Prakash</i> 3/115
5	<i>Naga</i> (Lead)	Diabetes, Tuberculosis, Jaundice	<i>Ayurveda Prakash</i> 3/188
6	<i>Manhashila</i> (As <sub>2</sub> S <sub>2</sub> )	Calculi, Dysuria, Burning Micturition, Constipation	<i>Ayurveda Prakash</i> 2/219
7	<i>Hartala</i> (As <sub>2</sub> S <sub>3</sub> )	Diabetes, Pyrexia, Blisters on skin, and even death	<i>Ayurveda Prakash</i> 2/179

pharmaceutical process of *Shodhana*. If its toxicity occurs in the body then *Meshshringi* is recommended with sugar for 3 days to remove its toxicity from the body

- Raw sulfur gets purified with the treatment of cow's milk and ghee and to remove its toxicity from the human body cow's ghee and milk are recommended
- Raw *Hartala* (Arsenic trioxide; As<sub>2</sub>S<sub>3</sub>) gets purified with *Kushmand Swarasa* (*Benincasa hispida*) and to remove its toxicity *Kushmand Swarasa* is recommended with

*Jeerak* (*Carum carvi*) and *Madhu* (Honey)

- Raw *Gauripasan* (arsenious oxide; As<sub>2</sub>O<sub>3</sub>) gets purified with *Tankan* (borax) and cow's milk and to remove its toxicity from body same is recommended.

#### Method II<sup>[24]</sup>

Another prospective "LIKE TREATING LIKE" with the concept snake venom is itself used in snake poisoning. Here,

also toxicity if caused by medicines made from improper processed metals and minerals then another *Ayurvedic* formulations used to remove its toxicity.

1. Borax and turmeric were also known to have a powerful anti-dote effect
2. If purified arsenious oxide (*Gauripasan*) caused some toxicity then borax (*Tankan*) with cow's milk used as antidote for it
3. If prepared medicine made from lead (*Naag*) cause some toxicity, then medicine prepared from gold (*Swarna Bhasma*) with *Termenelia chebula* powder used as antidote
4. If purified copper (*Tamra*) cause some toxicity, then arsenious oxide (*Gauripasan*) with sugar recommended as antidote.

## CHELATING AGENTS OR ANTIDOTES OF INDIAN SYSTEM OF MEDICINE

Antidotes or chelating agent that are described in *Ayurveda* classics that help to remove poison caused by metals, minerals, and poisonous plants are tabulated in Tables 4 and 5,<sup>[9,24]</sup> respectively. Some researches have been done on various natural agents, which clearly shows that they have potential in the form of some chemicals and molecules to remove toxicity caused by metals and minerals by any cause.<sup>[6,9,25,26]</sup> These agents had already been practiced by ancient scholars. Some of those researches are described below.

## Garlic<sup>[25]</sup>

Garlic in different forms has antioxidant properties. These properties are shown to be due to the existence of compounds such as water-soluble organosulfur compounds, S-allylcysteine, and lipid soluble compounds like diallyl-sulfide. It shows phenomenal ameliorating properties against heavy metal poisoning due to its possession of chemicals containing organo-sulfur groups, volatile oils, enzymes, carbohydrates and amino acids, garlic was extensively exploited to treat the metal-induced toxicities. Recent supportive evidence indicate that garlic contains compounds capable of detoxifying lead, cadmium, methylmercury, phenylmercury and arsenic. The restorative property of garlic was attributed to its antioxidant activity and/or chelating efficacy. It has long been acknowledged that sulfhydryl-containing compounds have the ability to chelate metals. The sulfur-containing amino acids methionine and cysteine, N-acetylcysteine, an acetylated analog of cysteine, the methionine metabolite S-adenosylmethionine,  $\alpha$ -lipoic acid, and the tripeptide glutathione (GSH) all contribute to the chelation and excretion of metals from the human body.<sup>[6]</sup> The clastogenic effects of the heavy metals were also pronouncedly reduced by dietary administration of garlic. Fatal effects with respect to body metal burden, oxidative stress, and mitochondrial injury were effectively reduced by garlic. The curative effect of garlic was superior to those of 2,3-dimercapto-1-propanol and D-penicillamine,

**Table 4:** Antidotes vis-à-vis Chelating agents as described in *Ayurvedic* Classics to remove toxicity caused by administration *Bhasma* (if improperly processed)

S.no	Metals/Minerals	Chelating agent/antidote	Reference
1	Rasa/Parad (Mercury)	Gandhaka (Sulphur) with Nagvalli (piper betel)	Rasa Raj Sundar
2	Swarna (Gold)	Haritaki ( <i>Termenelia chebula</i> ) with sita (sugar)	Rasa Raj Sundar
3	Tamra (Copper)	Dhaniyaka ( <i>Coriander</i> ) with sita (Sugar)	Brihad Rasa Rajsundur
4	Naga (Lead)	Swarnabhasma (Gold ash) mix with Haritaki ( <i>Termenilia chebula</i> ) and sita (Sugar)	Rasa Rajsundar
5	Vanga (Tin)	Meshringi ( <i>Gymnema sylvestre</i> ) with sita (Sugar)	Rasa Rajsundar
6	Hartala ( $As_2S_3$ )	Jeerak ( <i>Carum carvi</i> ) with sita (Sugar)	Rasa Rajsundar
7	Manhashila ( $As_2S_3$ )	Cow's milk with Honey	Rasa Taringini
8	Abhrak (Biotite)	Atisi Beej	Rasa Jalnidhi
10	Vimal (Iron Pyrite)	Meshringi ( <i>Gymnemasyvestre</i> ) wih sita	Brihad Rasa Rajsundar
11	Sashayak (Blue Vitroil)	Jambiri nimbu	Brihad Rasa Rajsundar
12	Rasak (Zinc Oxide)	Gomutra (Cow's urine)	Brihad Rasa Rajsundar
13	Gandhak (Sulphur)	Godudha (Cow's milk) with Goghrita (Cow's Ghee)	Brihad Rasa Rajsundar
14	Gauripashana (White arsenic)	Tankan (Borax) Godudha (Cow's milk) with Goghrita (Cow's Ghee)	Ayurvedic Rasashastra
15	Loha (Iron)	Agastya swarasa ( <i>Sesbaniagrandiflora</i> ) with Vidang ( <i>Embelia ribes</i> )	Ayurveda Prakash
16	Yashad (Zinc)	Bala ( <i>Sida cordifolia</i> ) mixed with Haritaki ( <i>Termenelia chebula</i> ) and sugar	Rasa Rajsundar
17	Makshik (Copper Pyrite)	Kullatha kwatha ( <i>Dolichus biflorus</i> ) and Dadima Kwatha ( <i>Punica granatum</i> )	Brihad Rasa Rajsundar

**Table 5:** Antidotes vis-à-vis Chelating agents for poisonous herbs used in *Ayurveda* for therapeutic uses

S. No	Plants	Antidotes/Chelating agents
1	<i>Vatsanabha</i> ( <i>Aconitum ferex</i> )	<i>Borax with clarified Butter</i> <i>Borax with clarified Butter and Turmeric Juice</i>
2	<i>Ahiphen</i> ( <i>Papaver somniferum</i> )	<i>Ginger Juice</i> <i>Asfoetida water</i>
3	<i>Jayphala</i> ( <i>Croton tiglium</i> )	<i>Coriander Juice with Sugar</i>
4	<i>Dhatura</i> ( <i>Dhatura stramonium</i> )	<i>Acorus Calamus</i> ( <i>Vacha</i> ) <i>powder with curd</i> <i>Ricinus communis</i>
5	<i>Bhang</i> ( <i>Cannabis indica</i> )	<i>Butter Milk</i> <i>Curd with ginger powder</i>
6	<i>Bhallatak</i> ( <i>Semicarpus anacardium</i> )	<i>Coriander</i> <i>Termanalia arjuna</i> <i>Coconut water</i>
7	<i>Ark Ksheer</i> (Latex of <i>Calotropis procera</i> )	<i>Cow's ghee (clarified butter)</i>
8	<i>Vistundaka</i> ( <i>Strychnos nuxvomica</i> )	<i>Cow's ghee (clarified butter)</i>

2,3-dimercaptosuccinic acid and N-acetyl-DL-penicillamine, and the current remedies. In *Ayurvedic* literature garlic used in purification of impure mercury.<sup>[9]</sup>

### Boron<sup>[26]</sup>

Boron is considered to be essential micronutrient with its well established biological functions, and the antioxidant effects of boric acid are controversial. However, the potential of important boron compounds in cellular activities remains unexplored. One of the papers published on boron in experimental and toxicology pathology clearly showed that heavy metal treatments increased the frequencies of sister chromatid exchange micronuclei in the DNA of lymphocytes and the plasma malondialdehyde level; decreased the antioxidant enzyme activities. Whereas, the tested boron compounds (5-20 ppm) significantly reduced the genotoxic effects induced by low doses of heavy metals. Their results revealed that the protective roles of boron compounds occurred with the effectiveness on their anti-oxidant capacity. In conclusion, these compounds could be useful in the development of functional food and raw materials of medicine. In *Ayurvedic* literature also borax used as antidote in poisoning.

### GSH<sup>[25]</sup>

GSH is another potent chelator involved in cellular response, transport, and excretion of metal cations and is a biomarker

for toxic metal overload. Detoxifying process naturally generate large amounts of free radicals which combats by making antioxidant enzymes, glutathione-S-transferase (GST), glutathione peroxides (GPOX), and superoxide dismutase (SOD). These endogenous antioxidants are GSH and selenium-dependent. It is known that where there are high levels of toxic metals; there are low blood levels of GST, GPOX, SOD. GSH and selenium in the diet are precursors to these anti-oxidant enzymes. The cofactors to methylation include Vitamin B12, B6 and folic acid in the production of GSH. GSH is protein found in foods. Food rich in GSH is asparagus, walnuts, avocado,<sup>[27]</sup> and raw milk of goat (mentioned in *Ayurvedic* classics).<sup>[28]</sup>

### Coriander<sup>[25]</sup>

Coriander removes mercury, lead and other heavy metals cilantro (leaves of *Coriandrum sativum*), a popular culinary and medicinal herb, gained attention when soup was reported to enhance mercury excretion following dental amalgam removal and remains popular despite limited evidence. In animals, it decreased lead absorption into bone and inhibition of the delta-aminolevulinic acid dehydratase enzyme. Less encouragingly, in a recent trial in 3- to 7-year-old children exposed to lead, a cilantro extract was as effective as placebo in increasing renal excretion (improvements across treatment and placebo groups were ascribed to improved diet during the intervention). They can remove mercury and other heavy toxic metals from the body. In particular, coriander seems to be the only chelating agent that can remove these metals from the central nervous system. This makes it useful for people who want to detoxify after the removal of mercury tooth fillings, or to those who have been exposed to high levels of lead. Coriander contains antioxidants, with the leaves having the highest levels.<sup>[29]</sup>

## CONCLUSION

The cations, anions, ligands, etc. are the basis of chelation therapy, which are used in contemporary science. However, these terms were not known/ discovered at the classical treasure of *Ayurveda*. But, in spite of that various methods, and substances were used as antidotes, which played the dynamic role in removing the toxins from the body. Researches showed that some of these chelating agents of *Ayurveda* have the potential to detoxify the body from metal toxicity. Now it's time to do more research on these chelating agents of *Ayurveda* to prove their potency for detoxifying the body from metal toxicity. Reverse pharmacology for these chelating agents of *Ayurveda* will go to proof the efficacy of these precious agents of *Ayurveda*, and they will detoxify the body without causing any harm to other essentials minerals of the body.

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